EFFECTS OF TEMPERATURE AND LIGHT ON AERIAL BREATHING OF THE SHORTNOSE GAR, *LEPISOSTEUS PLATOSTOMUS*[1]

VISHNU P. SAKSENA

Department of Biology, Muskingum College, New Concord, Ohio 43762

SAKSENA, VISHNU P. Effects of Temperature and Light on Aerial Breathing of the Shortnose Gar, *Lepisosteus platostomus*. Ohio J. Sci. 75(4): 178, 1975.

The aerial breathing rate of the shortnose gar (*Lepisosteus platostomus*), as affected by temperature and light, was investigated by using an E & M Physiograph. Aerial breathing of the three small and the two large fish was simultaneously recorded at 10.0°, 15.5°, 21.1°, and 26.6°C. The rate of aerial breathing increased with increase in temperature. Between 10.0° and 15.5°C, the average aerial breathing rate was less than one per hour but beyond 15.5°C the rate increased markedly. At all experimental temperatures, the larger fish had a significantly higher aerial breathing rate than the smaller fish. The average aerial breathing rate of each experimental fish was consistently higher during the night than during the day. In an experiment at 21.1°C, the aerial breathing rate was higher during darkness than during equal periods of light regardless of whether the darkness occurred in natural day or night. Although, the shortnose gar did not exhibit a natural diurnal rhythm of aerial breathing, they seemed relatively more active at night. This observed higher activity may account for their higher breathing rate in darkness.

Gars (*Lepisosteus*) have infrequently been observed to approach and thrust their jaws above the water surface (Wilder, 1876; Mark, 1890; Potter, 1926). The first experimental evidence which demonstrated that gars are air-breathers was reported by Potter (1927). Recently, Winston (1967), de Roth (1973), and Saksena (1975) have studied the effects of temperature and light on the aerial breathing of the alligator gar (*L. spatula*), the spotted gar (*L. oculatus*), and the longnose gar (*L. osseus*) respectively. Horn and Riggs (1973) reported a similar study on the bowfin (*Amia calva*) and Hunt (1960) studied the feeding activity of the Florida gar (*L. platyrhincus*). Studies concerning physiology of respiration among gars have been reported by McCormack (1967, 1970) and Rahn *et al.* (1971).

The present study evaluates the effects of temperature and light on the rate of aerial breathing of the shortnose gar (*L. platostomus*) under experimental conditions.

MATERIALS AND METHODS

Three small (A, B, and C) and two large (D and E) shortnose gar (*L. platostomus*) were collected on June 14, 1967 from Lake Texoma, an impoundment of the Red and Washita Rivers, Oklahoma and Texas. The fish were brought to the University of Oklahoma Biological Station and were held in a large concrete tank, filled with lake water for two weeks until the start of the experiment. The weight and total length of each gar was: A—30.7 gms, 255 mm; B—50.2 gms, 300 mm; C—43.2 gms, 251 mm; D—681 gms, 612 mm; and E—784 gms, 605 mm. The mean weight and total length for small and large fish were 41.4 gms, 268.7 mm and 732.5 gms, 608.5 mm respectively.

Each fish was placed in a separate 50 gallon aquarium filled with lake water. The rubber mesh aquarium covers prevented the fish from jumping out and allowed for ventilation. The aquaria were not shielded and light was permitted to enter from all sides. Experimental studies were conducted in a controlled temperature room illuminated by six 3F40 cool-white fluorescent lights. The lights were automatically turned on or off at desired intervals.

An E & M Physiograph was used to record the aerial breathing of shortnose gar following the method by Saksena (1975). This instrument provided a continuous, time-correlated, simultaneous recording of the aerial breathing of five fish in both light and darkness.

Experimental Procedure. Three small (A, B, and C) and two large (D and E) shortnose gar were introduced into the experimental aquaria at room temperature (23.9°C). The room temperature was then gradually lowered to 10.0°C over a six-day period and the fish were acclimated for 72 hours before recording of aerial breathing started. The aerial breathing rates of shortnose gar were recorded for 72 hours each at 10.0°, 15.5°, 21.1°, and 26.6°C. The temperature was raised in a step-wise fashion by 5.5°C intervals allowing at least 72 hours for acclimation at each experimental temperature. During acclimation periods, the fish were fed live minnows. Lights were turned on automatically from 6 a.m. to 6 p.m. and off from 6 p.m. to 6 a.m. The dissolved oxygen in the

[1]Manuscript received October 16, 1974, revised February 20, 1975 (#74-44).

aquaria was monitored using the standard Winkler method.

The experiments were conducted in equal periods of light and darkness, so the data simultaneously provided information on effects of light and of temperature on aerial breathing rates. To determine whether aerial breathing rate is affected strictly by the presence or absence of light rather than the natural diurnal cycle, an additional experiment was conducted at 21°C. The light was off during the day (6 a.m. to 6 p.m.) and on during the night (6 p.m. to 6 a.m.) for the entire 72-hour recording period.

RESULTS

Effects of Temperature. In general, aerial breathing rates of small and large shortnose gar increased as temperature increased (fig. 1). At 10.0°C, the average aerial breathing rate per hour was practically negligible (approaching zero). The rate (less than one breath/hour) increased slowly as the temperature was raised to 15.5°C, but above 15.5°C the rate of aerial breathing increased markedly. At lower temperatures (10.0° and 15.5°C) the shortnose gar remained practically motionless on the bottom of the aquaria except when infrequently rising to the surface for aerial breathing. In Oklahoma, shortnose gar in their natural habitat have not been observed coming to the surface to breathe during the winter months. At low temperatures (10.0°C and below) they apparently remain in deeper waters and do not surface for aerial breathing.

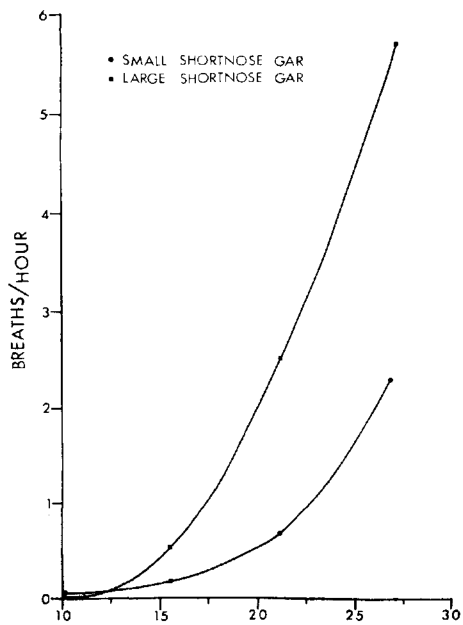

FIGURE 1. The relationship of temperature to average daily aerial breathing rate of 3 small and 2 large short nosed gar (*L. platostomus*).

At each temperature above 10°C, aerial breathing rates for large fish are higher than those for small fish (table 1). The analysis of data by the Mann-Whitney U Test (Siegel, 1956) confirms the significance of this difference.

The regression equations for the small and large shortnose gar are $\log(Y+1) = -0.3020 + 0.02718X$ and $\log(Y+1) = -0.5399 + 0.05022X$ respectively, when Y = breaths/hour and X = temperature (°C).

Effects of Light. With experimental temperatures (10.0 to 26.6°C), aerial breathing rates of all shortnose gar generally were higher during the night than during the day. The data for the average daily aerial breaths per hour as well as averages for night and day are summarized in table 1.

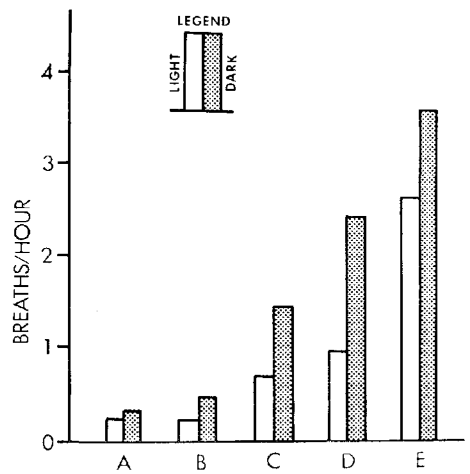

FIGURE 2. Comparison of the average hourly rate of aerial breathing of shortnose gar (*L. platostomus*) in light and in darkness at 21.1°C when lights were on from 6 p.m. to 6 a.m. and off from 6 a.m. to 6 p.m. based on a 72-hour recording. A, B, and C were small and D, E were large specimens.

TABLE 1

Average number of daily aerial breaths per hour and during successive periods of day (6 a.m. to 6 p.m.) and night (6 p.m. to 6 a.m.) of five shortnose gar (L. platostomus) *at four temperatures.*

Temperature °C	Average breaths per hour					
	24-hour period	S.D.*	Day	S.D.	Night	S.D.
	Shortnose Gar A					
10.0	0.069	±0.034	0.000	±0.000	0.136	±0.026
15.5	0.222	±0.028	0.166	±0.000	0.278	±0.026
21.1	0.292	±0.087	0.139	±0.103	0.444	±0.152
26.6	0.653	±0.184	0.278	±0.036	1.028	±0.238
	Shortnose Gar B					
10.0	0.055	±0.041	0.000	±0.000	0.111	±0.103
15.5	0.153	±0.039	0.111	±0.103	0.194	±0.146
21.1	0.430	±0.171	0.222	±0.142	0.639	±0.432
26.6	3.417	±0.695	2.417	±0.604	4.417	±1.110
	Shortnose Gar C					
10.0	0.028	±0.029	0.000	±0.000	0.056	±0.055
15.5	0.181	±0.050	0.111	±0.026	0.250	±0.084
21.1	1.278	±0.202	0.972	±0.282	1.583	±0.173
26.6	2.764	±0.245	2.350	±0.127	3.218	±0.720
	Shortnose Gar D					
10.0	0.000	±0.000	0.000	±0.000	0.000	±0.000
15.5	0.264	±0.071	0.167	±0.048	0.361	±0.153
21.1	1.764	±0.191	1.389	±0.041	2.139	±0.120
26.6	4.278	±0.280	3.861	±0.342	4.694	±0.320
	Shortnose Gar E					
10.0	0.014	±0.000	0.000	±0.000	0.028	±0.026
15.5	0.819	±0.078	0.667	±0.048	0.972	±0.073
21.1	3.278	±0.232	2.917	±0.240	3.639	±0.294
26.6	7.126	±0.280	3.861	±0.342	4.694	±0.720

*S.D. = Standard Deviation.

The results of the experiment conducted at 21.1°C, in which the fish were exposed to 12-hour alternate periods of light and darkness under reversed natural diurnal rhythm, are shown in figure 2. Each fish in this experiment exhibited higher rates of aerial breathing during periods of darkness than during equal periods of light. Apparently shortnose gar have a higher rate of aerial breathing during darkness than in light, irrespective of whether darkness occurs during natural day or night time.

DISCUSSION AND CONCLUSION

In general, the rate of aerial breathing of shortnose gar (*L. platostomus*) increased with temperature. Similar results were obtained for the alligator gar (*L. spatula*) (Winston 1967), the spotted gar (*L. oculatus*) (de Roth 1973), the longnose gar (*L. osseus*) (Saksena 1975), and the bowfin (*Amia calva*) (Horn and Riggs 1973).

Several species of fishes have been reported to be more active at night than during the day (Darnell and Meierotto, 1965; Grigg, 1965; Carlander and Cleary, 1949; Sullivan and Fisher, 1947). The relationship between aerial breathing in light and dark conditions seems to differ among air-breathing fishes. At temperatures higher than 22.8°C, the alligator gar breathed more during the day than during the night (Winston, 1967). Similar to the shortnose gar, the spotted gar (between 12.8 and 26.6°C) (de Roth 1973), the longnose gar (above 12.2°C)

(Saksena 1975), and the bowfin (Horn and Riggs, 1973) had higher aerial breathing rates at night than during the day. The experimental fish, from visual observations and inspection of the Physiograph recordings, were relatively more active at night and perhaps this increased activity resulted in their higher rate of aerial breathing. Saksena (1963) found that induced swimming activity increased the rate of aerial breathing of the longnose gar.

The dissolved oxygen in the aquaria for small and large shortnose gars ranged from 5.84 to 4.88 mg/l (average 4.30 mg/l) and 4.96 to 2.48 mg/l (average 3.48 mg/l) respectively. According to Renfro and Hill (1970), even 3.0 mg/l dissolved oxygen content did not produce any ill effects on gars provided they were allowed to breathe air.

In general, the results in the present study of the shortnose gar (*L. platostomus*) closely parallel to the pattern found in several other species of *Lepisosteus* reported in the literature.

Acknowledgments. I am thankful to Dr. Carl D. Riggs, former Director, University of Oklahoma Biological Station, for his guidance in research. The project was done under the Research Participation for College Teachers' Program of the National Science Foundation.

LITERATURE CITED

Carlander, K. D., and R. Cleary. 1949. The daily activity patterns of some freshwater fishes. Amer. Midl. Nat. 41: 447–521.

Darnell, R. M., and R. R. Meierotto. 1965. Diurnal periodicity in the black bullhead, *Ictalurus melas* (Rafinesque). Trans. Amer. Fish. Soc. 94: 1–8.

de Roth, G. C. 1973. Effects of temperature and light on aerial breathing behavior of the spotted gar, *Lepisosteus oculatus*. Ohio J. Sci. 73: 34–41.

Grigg, G. C. 1965. Studies on the Queensland lungfish, *Neoceratodus forsteri* (Krefft). III. Aerial respiration in relation to habits. Austral. J. Zool. 13: 413–421.

Renfro, J. L., and L. G. Hill. 1970. Factors influencing the aerial breathing and metabolism of gars (*Lepisosteus*). Southwest. Nat. 15: 45–54.

Horn, M. H., and C. D. Riggs. 1973. Effects of temperature and light on the rate of air breathing of the bowfin, *Amia calva*. Copeia. 1973: 653–657.

Hunt, B. P. 1960. Digestion rate and food consumption of Florida gar, warmouth and largemouth bass. Trans. Amer. Fish. Soc. 89: 206–211.

Mark, E. L. 1890. Studies on *Lepidosteus*. Bull. Mus. Comp. Zool. Harvard Coll. 19: 1–127.

McCormack, B. T. 1967. Aerial respiration in the Florida spotted gar. Quart. J. Florida Acad. Sci. 30: 68–72.

——— 1970. Aerial and aquatic respiration in the Florida gar, *Lepisosteus platyrhincus*. M.S. Thesis, Univ. of Miami, Miami, Florida.

Potter, G. E. 1926. Ecological studies of the short-nosed gar-pike (*Lepidosteus platostomus*). Univ. Iowa Stud. Nat. Hist. 11: 17–26.

——— 1927. Respiratory function of the swim bladder in *Lepidosteus*. J. Exp. Zool. 49: 45–67.

Rahn, J., K. B. Rahn, B. J. Howell, C. Gans, and S. M. Tenney. 1971. Air-breathing in the gar fish. Resp. Physiol. 11: 285–314.

Saksena, V. P. 1963. Effects of temperature, light, feeding and activity on the rate of aerial breathing of gar (*Lepisosteus*). Ph.D. Dissertation, Univ. of Oklahoma, Norman, Oklahoma.

——— 1975. Effects of temperature and light on aerial breathing of the longnose gar, *Lepisosteus osseus*. Ohio J. Sci. 75: 58–61.

Siegel, S. 1956. Nonparametric statistics for the behaviorial sciences. McGraw-Hill Book Co., New York.

Sullivan, C. M. and K. C. Fisher. 1947. Temperature selection and the effects of light and temperature on movements in fish. Federation Proc. 6: 212–213.

Wilder, B. G. 1876. Notes on the North American ganoids, *Amia*, *Lepidosteus*, *Acipenser*, and *Polyodon*. Proc. Amer. Assoc. Adv. Sci. B. 24: 151–196.

Winston, W. D., Jr. 1967. Effects of temperature and light on the rate of aerial breathing of the alligator gar, *Lepisosteus spatula*. M.S. Thesis, Univ. of Oklahoma, Norman, Oklahoma.